

Environmental Water Account Expenditures for Chinook Salmon in Water Year 2005

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The EWA was used for three actions taken in 2004-2005 for juvenile salmon. These included pumping curtailments during Delta Action 8 in early December 2004, the Vernalis Adaptive Management Plan (VAMP) in May 2005, and for several days in early June after the VAMP period. B(2) water was used concurrently with the EWA during some of these periods. Authorized levels of incidental take for winter-run and spring-run Chinook salmon at the SWP/CVP were not exceeded; hence the EWA was not used in 2004-2005 for the purpose of minimizing take of these listed species in the context of avoiding reconsultation under the ESA.

Delta Action 8

Delta Action 8 was initiated to answer the question: Should exports be reduced in the November – January period from the present 65% E/I ratio to 35% to protect juvenile salmon migrating through the Delta at that time.

During Data Assessment Team (DAT) calls in late November of 2004, it became apparent that the SWP and CVP would be reducing exports in December because there was no excess water in the system to pump. It was suggested then to limit exports to 4000 cfs during the experiment to gather more data at the relatively lower export rate. Estimated water cost for that scenario was deemed reasonable (~40,000 acre feet) and could be covered by EWA and B2 assets, but there weren't many wild salmon migrating into the Delta from upstream at this time to benefit from the lower exports. Ultimately, the request was to keep exports stable for the 10-14 days, using EWA and b(2) assets to cover costs. Exports were projected to be about 6000 cfs for the 10 day period. The original suggestion to evaluate 4000 cfs was dropped because 1) not many natural salmon were migrating into the Delta at the time – even though others had been observed earlier, and 2) Due to changes in base case conditions, the estimated cost had increased to about 90,000 acre feet. In response to discussions about what could have gained from an experimental data point at the lower export level, Wim Kimmerer conducted a power analyses (Figure 1). His results suggested that a 2000 cfs export rate experiment could have provided the most critical information needed in evaluating the relationship.

In December 2004, groups of coded wire tagged late-fall from Coleman National Fish Hatchery were released as part of Delta Action 8. Groups of marked fish were released in Georgiana Slough on 12/8 and at Ryde on 12/9 and at Port Chicago on 12/10.

Recoveries of fish from these release sites have been used to estimate relative interior Delta survival and which is then regressed against export conditions. The Port Chicago release was made to obtain absolute survival by factoring out ocean survival. In addition, to put these estimates of survival in context, several other releases were made (Figure 2). Fish were released on the Sacramento River at Sacramento on 12/6, and at Vorden (upstream of the DCC and Georgiana Slough, but downstream of Sutter and Steamboat Sloughs) on 12/7. An earlier release was made xxx miles upstream of the Delta in Battle Creek on 11/29. The Vorden release was made to evaluate the effect of Georgiana Slough when the DCC gates were closed when compared to Ryde and to estimate the effect of Steamboat and Sutter Sloughs when compared to the Sacramento release. The Sacramento releases were made to estimate survival through the Delta and by comparing recoveries from the Battle Creek release to the Sacramento release we could estimate survival in the Sacramento River between Battle Creek and the Delta. One other release was made at Sherman Island in 2004 to estimate absolute survival of upstream release groups from recoveries at Chipps Island. More background on all of the Delta Action 8 experiments and maps showing release sites are available at <http://www.delta.dfg.ca.gov/jfmp/patfiles.asp>

We requested that combined SWP/CVP exports be stable for the 10 day period following the Sacramento release on 12/6. While this was generally achieved, export levels at each of the two facilities changed over the period (Table 1). The EWA cost for manipulating SWP export for DA8 was 4,200 acre feet.

With the help of Jon Burau of USGS, we released the salmon from each of the two different tag codes contained within the Sacramento group 6 hours apart. This strategy was used so the two groups of coded wire tag fish would approach Steamboat and Sutter Sloughs on opposite phases of the tide. The tide influences the flow rate of water from the Sacramento River into Steamboat and Sutter Sloughs. In addition, drifters were released with the Vorden fish release to determine if they were diverted into Georgiana Slough when they reached that location. The Vorden release was made on the slack before the ebb tide. None of the salmon from the Vorden group was predicted to be diverted into Georgiana Slough based on the tide phase at the time the drifters passed Georgiana Slough and the fact that no drifters went into Georgiana Slough (Attachment 1). This seemed to be supported by the similarity of survival indices to Chipps Island of the Vorden and Ryde releases (Table 2).

Incorporating the 2004 results, the ratio of the Georgiana Slough survival relative to the Ryde survival (or recovery rate in the ocean fishery) continues to be weakly correlated to mean combined exports at the State Water Project (SWP) and Central Valley Project (CVP) for the three days after the Georgiana Slough release (Figure 3). The relationship using the ocean tag recovery information with only 11 data points has a higher p value and is statistically significant ($p < 0.05$) (Figure 4). The ocean information for the last three years is not complete because some of those fish are still out in the ocean and susceptible to recapture. The relationship using the same 11 points for the Chipps Island survival ratios is also significant at $p < 0.05$. The slope of the two lines are not different indicating their relationship to exports is similar. The fact that these two independent

sources of data indicate the same type of relationship with exports gives us more confidence that the response is real. The intercept of the regression lines are significantly different – indicating that the ocean index is predicting a somewhat higher ratio at any one flow (table 3) (Obreski, personal communication).

On May 27, 2004 a workshop on Delta Action 8 was conducted by the CALFED Science Program. Detailed background information was provided to all the participants prior to the workshop for their review (available at <http://www.delta.dfg.ca.gov/jfmp/patfiles.asp>). The three invited experts (Ken Newman, University of St. Andrews, Scotland; Russ Perry, University of Washington; and Bryan Manley, consultant statistician) provided write-ups on their suggestions for Delta Action 8. Newman's and Perry's write-ups are also available on the web site with the back-up materials. Manley provided some information via email. He indicated that the apparent relationship between interior Delta survival and exports is due to water temperature. However, the high relative interior Delta survival was observed when exports and temperatures were both low making it difficult to discern relative contributions of each factor. He suggested doing experiments with high exports and low temperatures. The Science Advisors recommended, in a follow-up interpretation of the workshop, that the Delta Action 8 experiment not be conducted in 2005-2006 because they felt we were not answering the critical question of how many fish are diverted into the central Delta. Despite this recommendation from the science advisors, we are planning on conducting a Delta Action 8 experiment in 2005-2006 for several reasons.

From the CALFED Science PSP, the USFWS received a grant to contract with a statistician to review the design, implementation and interpretation of the Delta Action 8 experiment. Before we decide to discontinue the experiment, we have elected to have this review take place. The review should be completed by December 2007. In addition, Russ Perry, Ken Newman and Brain Manley did not recommend suspension of the experiment in their comments.

The Delta Action 8 is an attempt to manipulate variables and test a hypothesis: Is relative interior Delta survival a function of exports? The proportion of water and presumably juvenile salmon diverted into the interior Delta is not a function of exports but one of tide, flow, channel velocity etc. We and others will continue to determine what proportion of juvenile salmon migrating down the Sacramento River are diverted into Georgiana Slough and the Delta Cross Channel when the gates are either open or closed. We have already learned some things from the Delta Cross Channel work team and are waiting for a report on their results and conclusions. In addition, they are proposing new work in the fall of 2006 to further understand how the fish split at that junction as well as in Steamboat and Sutter Sloughs. Dave Vogel is planning on working with them, using ultrasonic tags to evaluate the fish splits at the various junctions along the Sacramento River. In addition, Steve Lindley, Bruce MacFarlane and Peter Klemly will be funded through the CALFED Science PSP to use ultrasonic tags to track late-fall from the hatchery to the Golden Gate Bridge. We plan to collaborate with both of these groups as they implement their projects to further understand how juvenile salmon migrate through the Delta. We are exploring adding tags and receivers to Steve Lindley's project to get more information on the use of interior Delta migration routes than their proposed design would provide.

The Science Advisors recommended using the late-fall releases from Battle Creek to assess export impacts on survival through the Delta. Using these releases, by themselves, is problematic because there is a lot of variability in how long it takes these fish to migrate through the Delta making it difficult to determine what conditions they experienced in the Delta that contributed to their survival. In addition, survival in the Delta changes between years for many reasons and without a control group of some sort, none of these other variables can be factored out. The more focused Ryde/GS and Sacramento comparison used for the Delta Action 8 has attempted to limit this noise by pairing releases.

The highest priority for use of EWA assets in 2005-2006 is for delta smelt. We hope to conduct the 2005-2006 Delta Action 8 experiment in January 2006 if possible at low exports during an export curtailment for delta smelt. Alternatively, the experiment might be conducted at a high export rate. We only have three release groups (a total of 170,000) to release. We are planning on making a release of 70,000 in Georgiana Slough, 50,000 at Ryde and 50,000 at Port Chicago. Coordinating a series of hatchery releases on short notice is problematic, but we are talking to hatchery staff about this possibility.

VAMP Experiment

During the spring the VAMP experiment was conducted. This year, 2005, was the sixth year of a 12-year experiment. Spring flows in the San Joaquin River were too high to install a head of Old River Barrier (HORB). Nevertheless, the experiment with some modifications was still conducted. The VAMP is not only an experiment but also a protective measure for naturally produced juvenile salmon migrating from the San Joaquin basin tributaries.

Smolt survival estimates for the marked fish used in VAMP were significantly lower in 2003 and 2004 than in previous VAMP years (2000-2002). Assuming these results were representative of the survival of unmarked salmon migrating through the Delta we felt it was important to provide the best conditions possible for the juveniles out migrating in 2005. We felt three years of poor survival in a row would have severe adverse consequences for the basin's salmon populations. Relatively high river flows were expected to be helpful to migrating smolts. However, there would not be any added benefit from the HORB. We requested low exports to provide the most favorable conditions possible for the emigrating San Joaquin Basin salmon smolts in 2005.

The start of the VAMP period was delayed from the typical mid-April date to the beginning of May, in an effort to have San Joaquin River flow into the Delta as stable as possible. Having decreased steadily from about 15,000 cfs in early April to about 7,000 cfs in late April, the San Joaquin River flow at Vernalis ranged from about 7,500 – 9,000 cfs through mid May. Some of the upstream reservoirs were in flood control mode and making uncontrolled releases. Consequently, river flow increased to over 15,000 cfs again by the end of May as rain and snowmelt runoff increased.

A request for combined exports at 1,500 cfs for two weeks and then 3,000 cfs for the next two weeks was not implemented. Instead combined exports were about 2250 cfs for most of May. Because experimental fish were thought to be well downstream given the high river flow, export pumping was increased incrementally beginning May 27 through June 10 when the typical summer pumping rate of about 11,000 cfs was reached. The gradual increase was requested because naturally produced salmon smolts were still being detected emigrating from the San Joaquin basin through the southern Delta (Figure 5).

EWA costs for modifying SWP pumping were 134 taf in May and 34.7 taf in June.

Salmon smolt survival as indexed by the VAMP releases at Durham Ferry and Dos Reis, indicate survival was not significantly greater in 2005 than in 2003 or 2004, despite the increased flows (Figure 6). Exports were slightly higher in 2005 (~2250 cfs) than in 2003 and 2004 (1500 cfs).

Updated analyses from all of the VAMP experiments (and those south Delta experiments prior to VAMP) do show statistically significant relationships between flow and smolt survival from both Durham Ferry and Mossdale to Jersey Point with the HORB in place (Figure 7 and 8). The data without the HORB is more variable and not statistically significant although trends are consistent using the trawl and ocean recovery data, with survival increasing as flows increase (Figure 9 and 10). The ocean recovery data for smolts released at Dos Reis (on the San Joaquin River, downstream of Old River) and Jersey Point indicates the differential recovery rate increases as flows increase (Figure 11) ($p < 0.01$), indicating that the survival for the smolts that stay on the San Joaquin River when there isn't a HORB, will have higher survival as flows increase.

The role of exports on smolt survival has been problematic to identify. The VAMP design has two target conditions (exports at 1500 and 3000 cfs at 7000 cfs flows with the HORB) that were specifically included in the design to identify this relationship. Data need to be gathered at these target conditions to determine the export affect on smolt survival. Even though these target conditions are contained within the VAMP design for this purpose, they have not yet been tested due to hydrologic constraints in obtaining a 7000 cfs flow level.

Adult escapement data (1953-2004) indicate that flows and flows/export do account for a significant amount of the variability in adult escapement (all year classes) even with the noise associated with the varying year classes within annual escapement. More of the variability with escapement is accounted for using flow/exports than when using flow alone, when there was no HORB in place (Figures 12 and 13). The best relationship for escapement in the years when the HORB was in place is with flow alone, perhaps as a result of the narrow range of relatively low export levels (1,450 to 2,350 cfs) since these tests with the HORB have been conducted.

We expect the VAMP period export curtailment will occur in 2006 as it will coincide with a period of concern for delta smelt as well as juvenile salmon and conducting the VAMP experiment is part of a 12-year agreement.

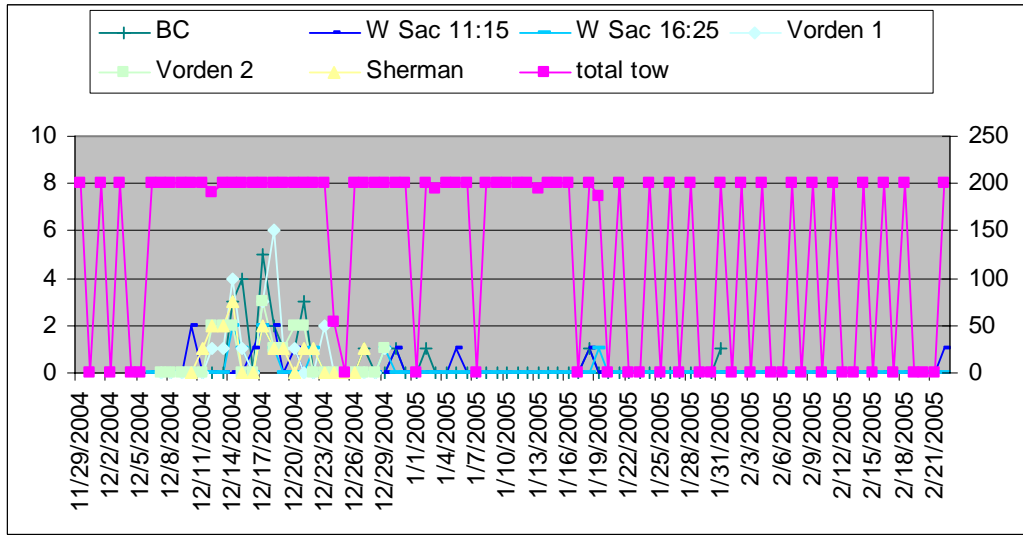
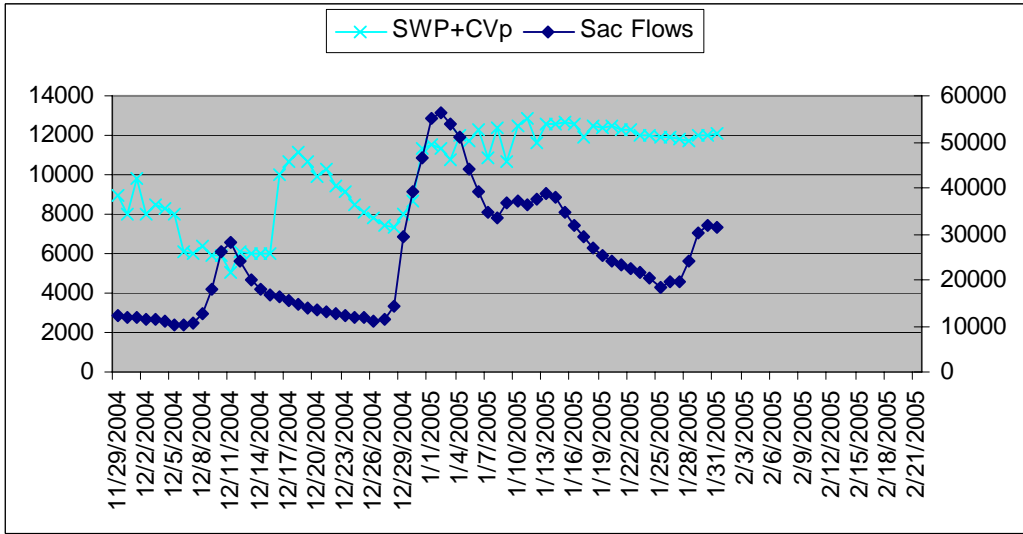
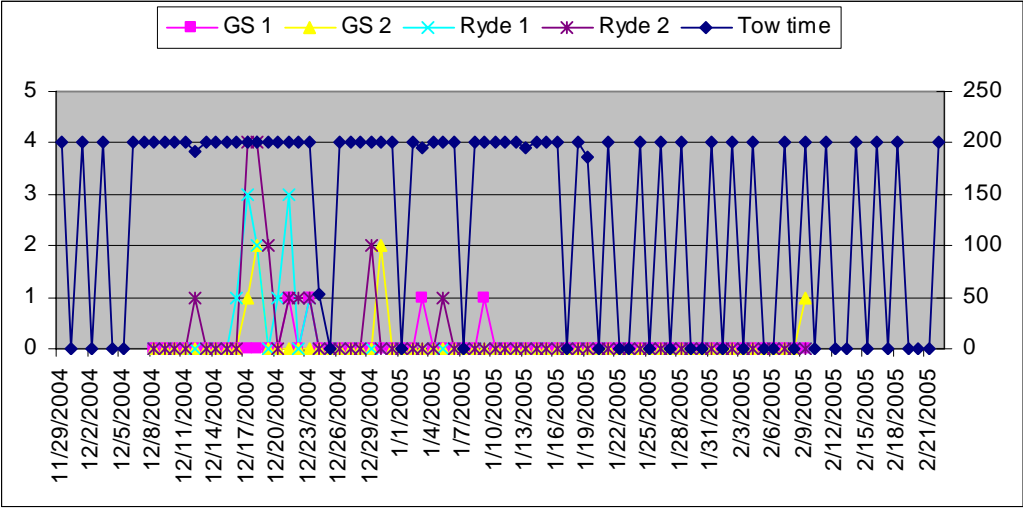


Table 1

Table 2: Survival indices of late-fall hatchery fish released upstream and in the Delta in December of 2004.

Tag Code	Release Site	Date	Truck Temp(F)	River Temp(F)	# Released	Average Size (mm)	First Catch	Last Catch	# Recovered	Minutes Fished	% Time Sampled	Survival Index	Group Index
05-22-76	Battle Cr.	11/29/04	N/P	N/P	69993	117	12/14/04	01/31/05	24	7430	0.105	0.423	
05-22-84	West Sacramento	12/06/04	50	48.2	25279	126	12/10/04	02/22/05	12	10021	0.093	0.665	
05-22-85	West Sacramento	12/06/04	50	47.3	25482	125	12/14/04	01/19/05	9	6430	0.121	0.380	
					50761		12/10/04	02/22/05	21	10021	0.093		0.578
05-22-90	Vorden Road	12/07/04	53.4	49	34007	130	12/12/04	12/29/04	21	3244	0.125	0.641	
05-22-91	Vorden Road	12/07/04	53.4	49	34413	117	12/12/04	12/29/04	16	3244	0.125	0.483	
					68420		12/12/04	12/29/04	37	3244	0.125		0.562
05-22-92	Georgiana Slough	12/08/04	54.5	48.2	36009	121	12/21/04	01/09/05	4	3248	0.113	0.128	
05-22-93	Georgiana Slough	12/08/04	54.5	48.2	36073	116	12/17/04	02/09/05	6	7630	0.096	0.224	
					72082		12/17/04	02/09/05	10	7630	0.096		0.188
05-22-80	Ryde	12/09/04	57.2	51.8	25202	134	12/16/04	12/23/04	11	1600	0.139	0.409	
05-22-81	Ryde	12/09/04	60.8	51.8	25195	128	12/12/04	01/05/05	17	4439	0.123	0.711	
					50397		12/12/04	01/05/05	28	4439	0.123		0.587
05-22-82	Port Chicago	12/10/04	55	54	25132	117	12/17/04	12/17/04	2	** no survival calculated past CI			
05-22-83	Sherman Island	12/10/04	57	51.8	25558	116	12/11/04	12/27/04	15	3044	0.124	0.614	

Table 3: Summary ancova tables

The output directly below indicates that there is a significant difference among the intercepts of the two regressions - note however that $p = 0.0377$ which is rather high.

Differences Among Adjusted Means:

	Source	df	SS	MS	F	P
	Adj. means	1	0.20294	0.20294	4.989	0.0377
	Within	19	0.77285			
			0.04068			

The output directly below indicates that there is no significant difference among between the slopes of the two regressions - with $p = 0.6573$.

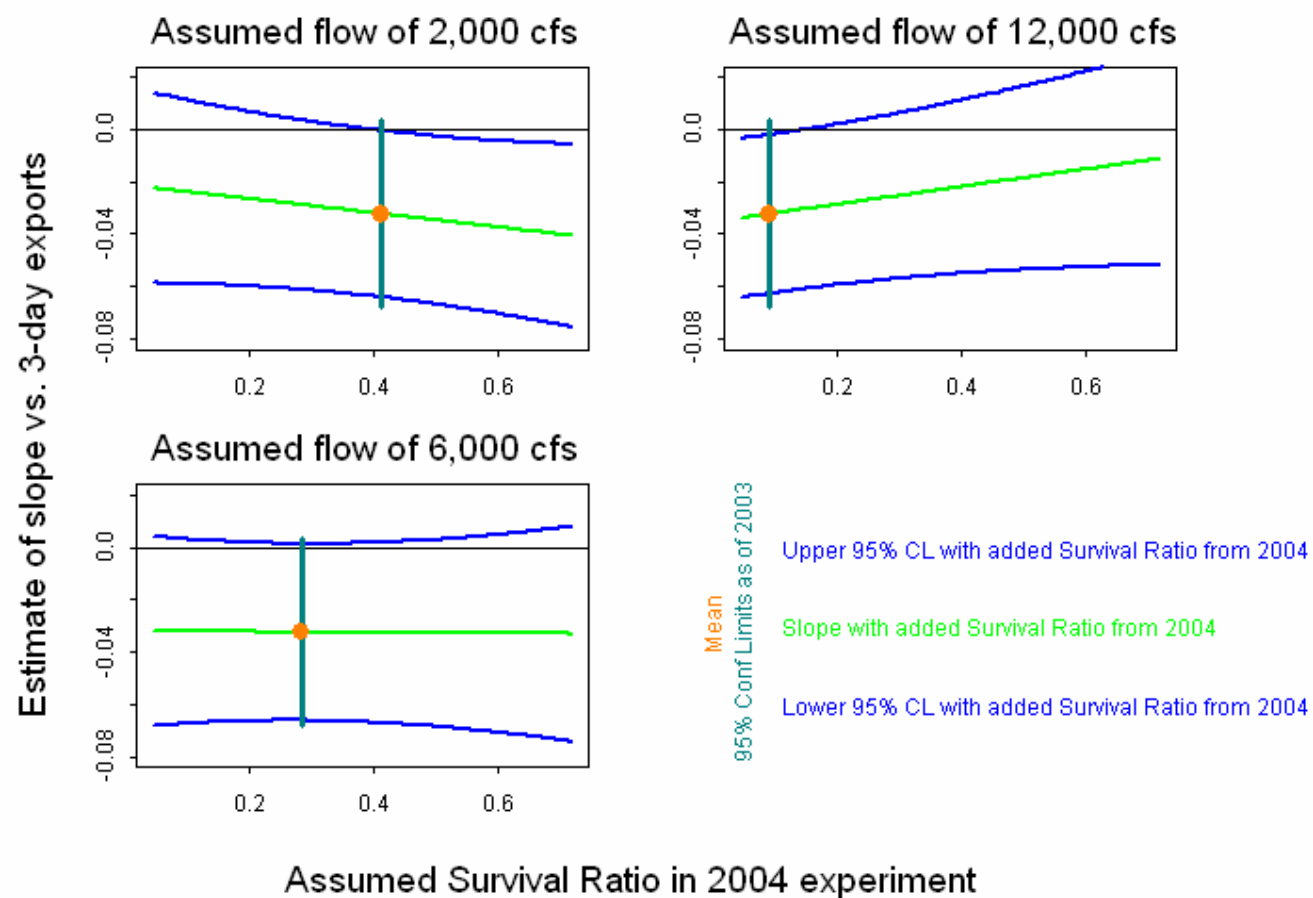
Common slope = -
0.00004

Differences Among Slopes:

	Source	df	SS	MS	F	P
	Among b_i	1	0.00864	0.00864	0.203	0.6573
	Sum of grp. dev.	18	0.76421			
			0.04246			

Power analysis of 2004 Delta Action 8 Experiment

Slopes estimated using mean export flow 1-3 days after release



20 December 2004: W. Kimmerer

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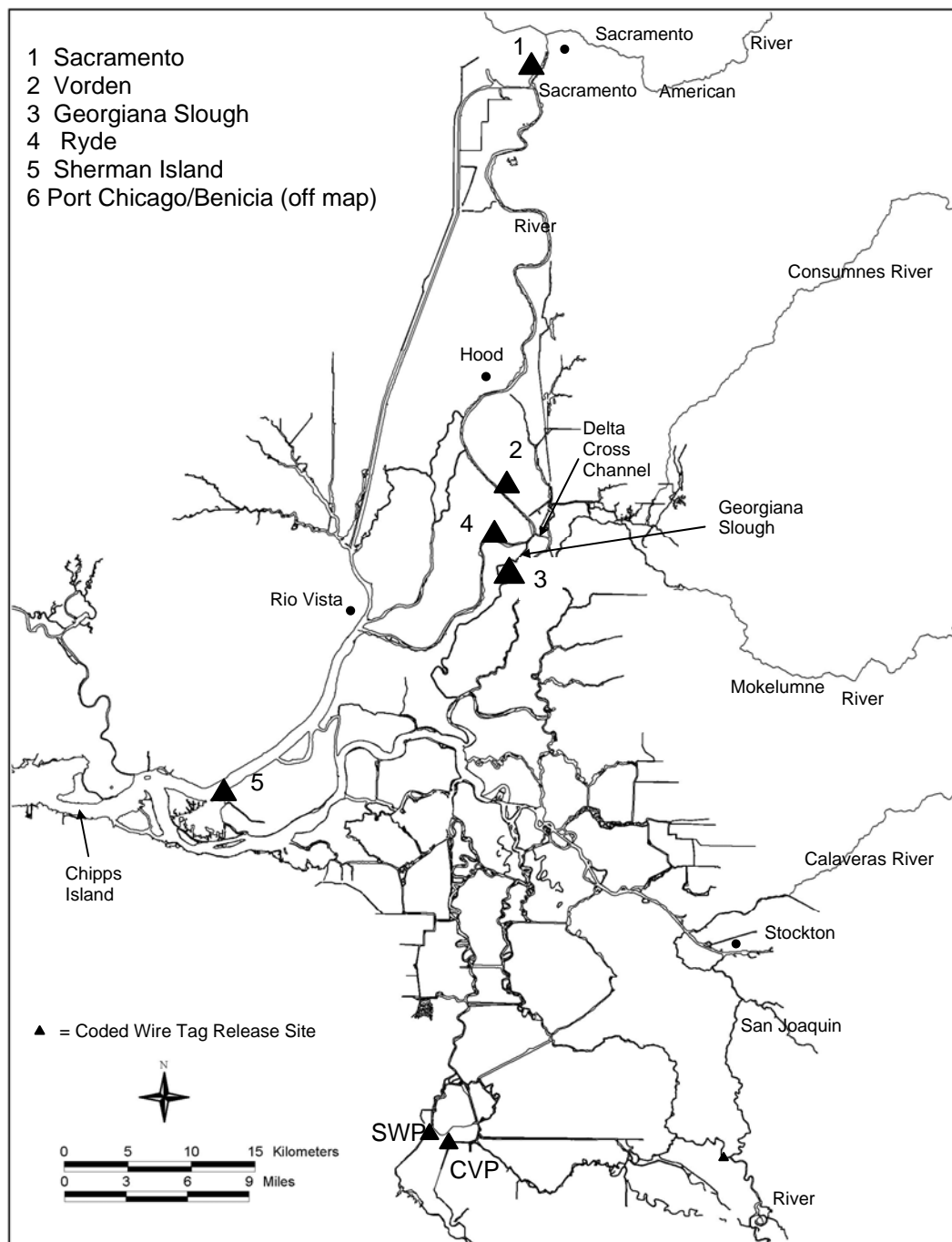


FIGURE 2: Detailed map of the Sacramento-San Joaquin Delta indicating coded wire tag release locations used in December of 2004 (triangles).

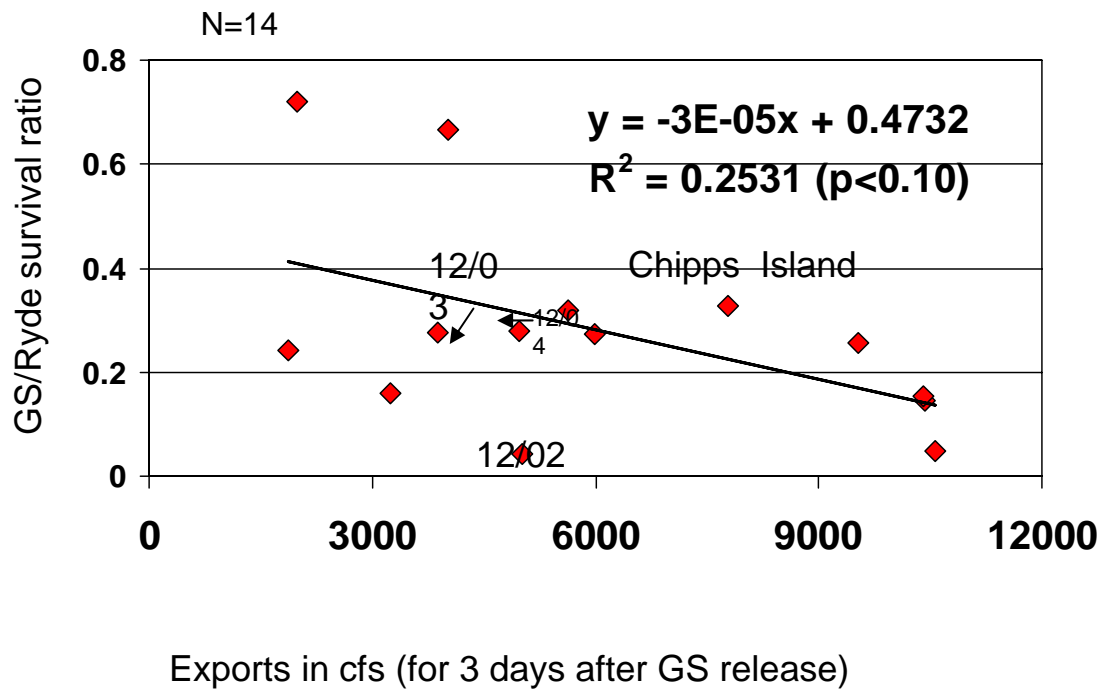
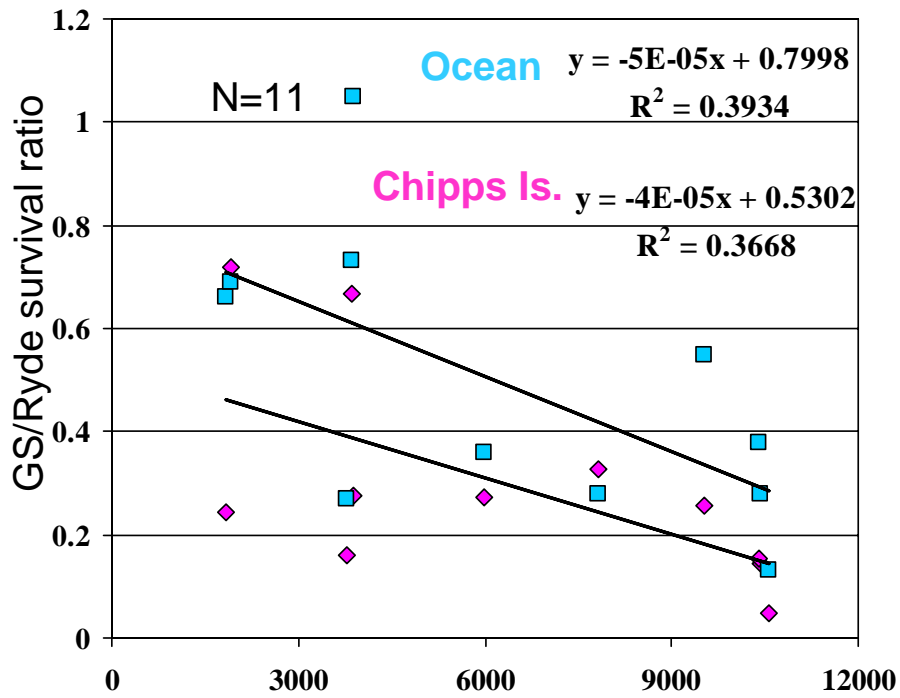


Figure 3: Relationship between GS/Ryde survival ratio (using Chipps Island survival indices) and combined exports 3 days after the Georgiana Slough release

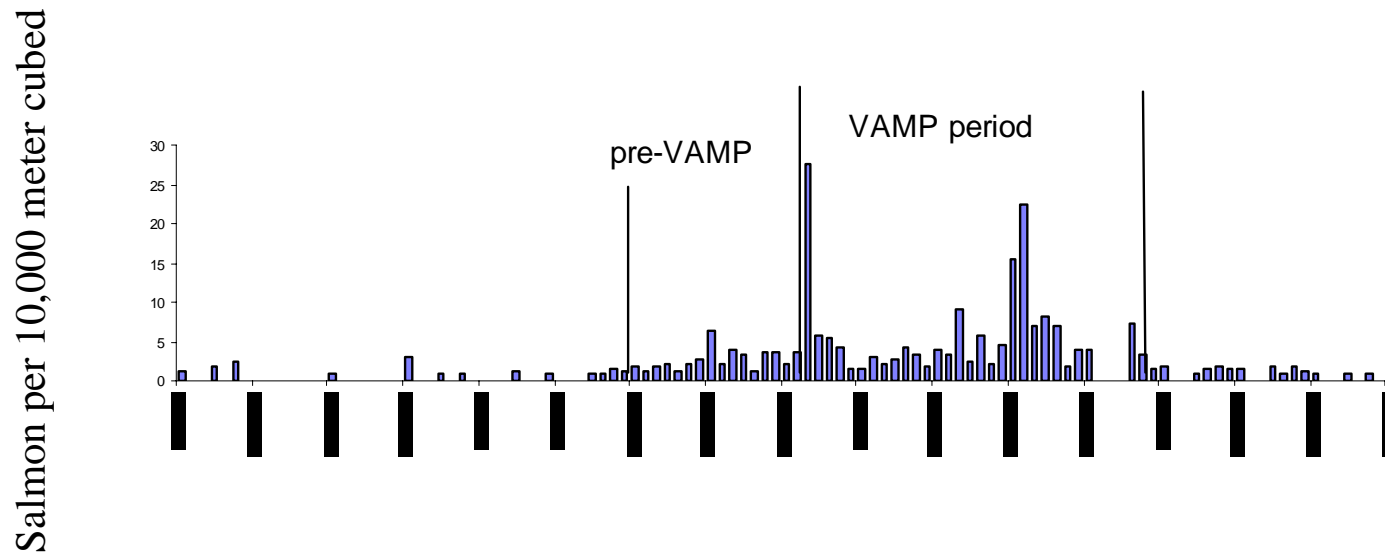


Exports in cfs (for 3 days after GS release)

Figure 4: Relationships between GS/Ryde survival ratio (using Chipps Island and ocean recovery indices) and combined exports 3 days after the Georgiana Slough release between 1993 and January of 2002

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Figure 5. The average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl on the San Joaquin River during the pre-VAMP and VAMP periods.



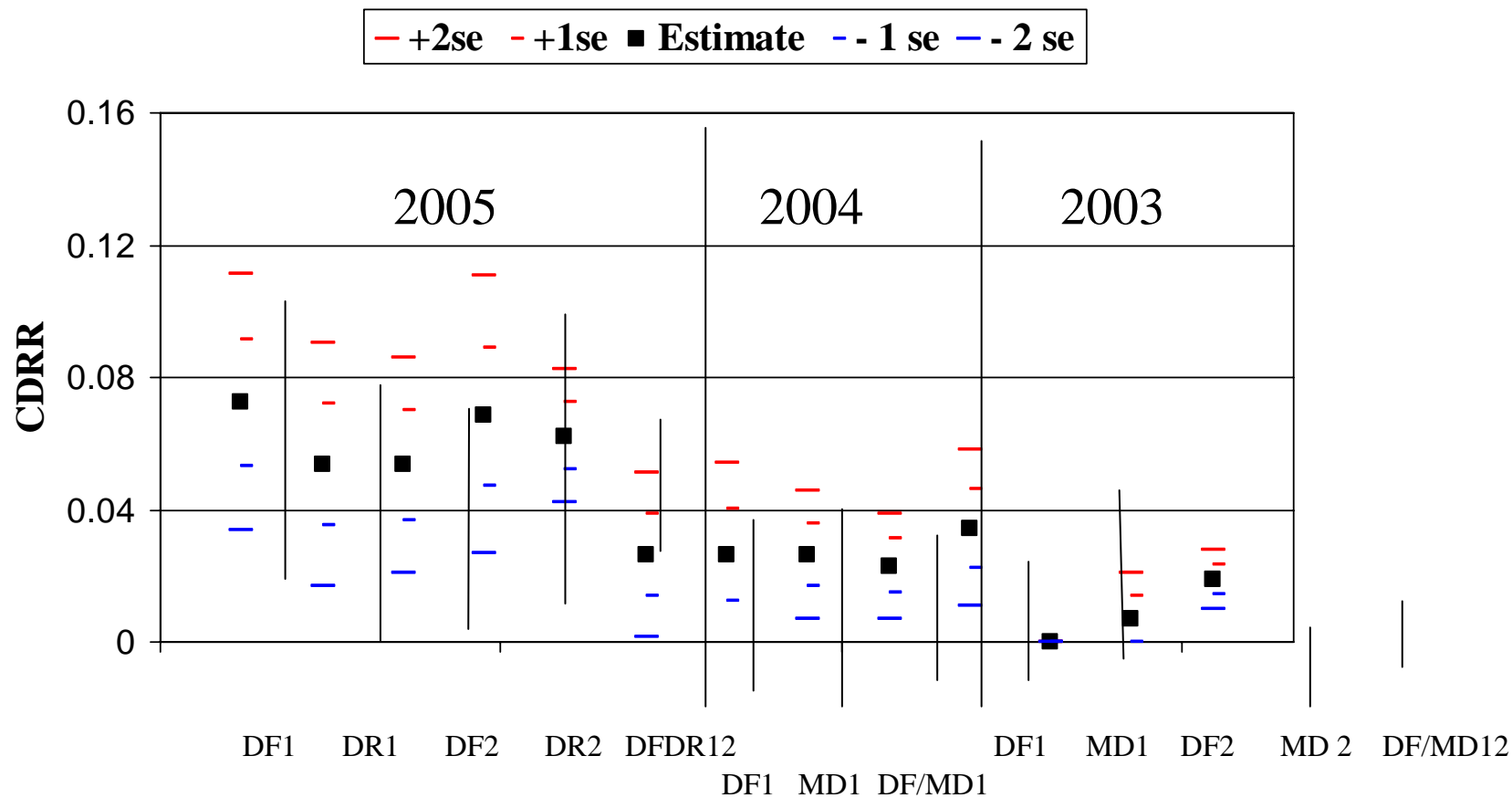


Figure 6 : Combined Differential Recovery Rates (CDRR) (+ / - 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF), Mossdale (MD) and Dos Reis (DR) relative to those released at Jersey Point for the first (1), second (2) and combined release groups in 2003, 2004 and 2005. Only one set of releases was made in 2004.

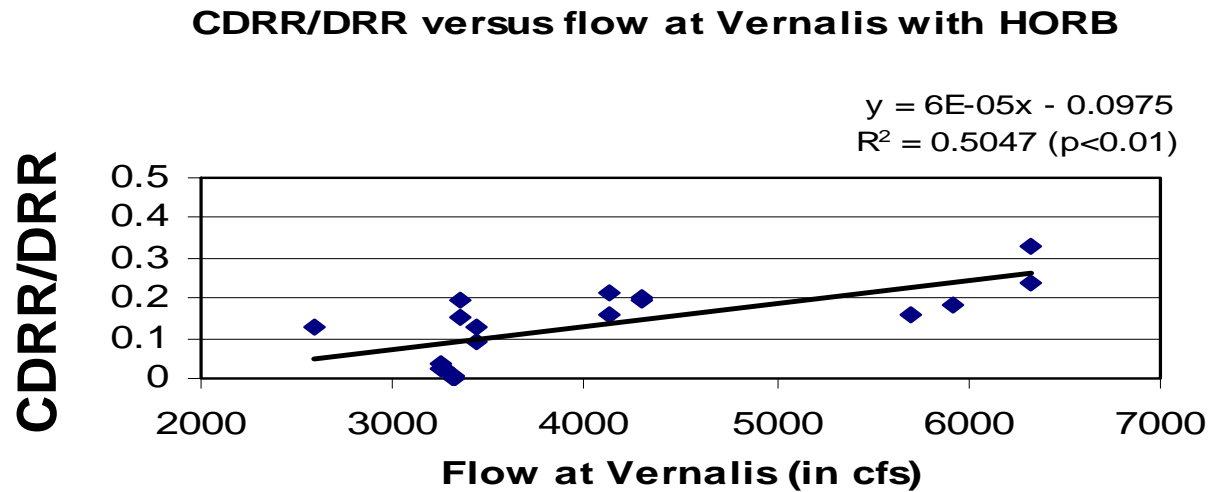


Figure 7: CDRR (Antioch and Chipps recoveries) or DRR (Chipps Island recoveries) between Mossdale or Durham Ferry and Jersey Point with the barrier in place and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release.

Ocean DRR versus Vernalis flow with HORB

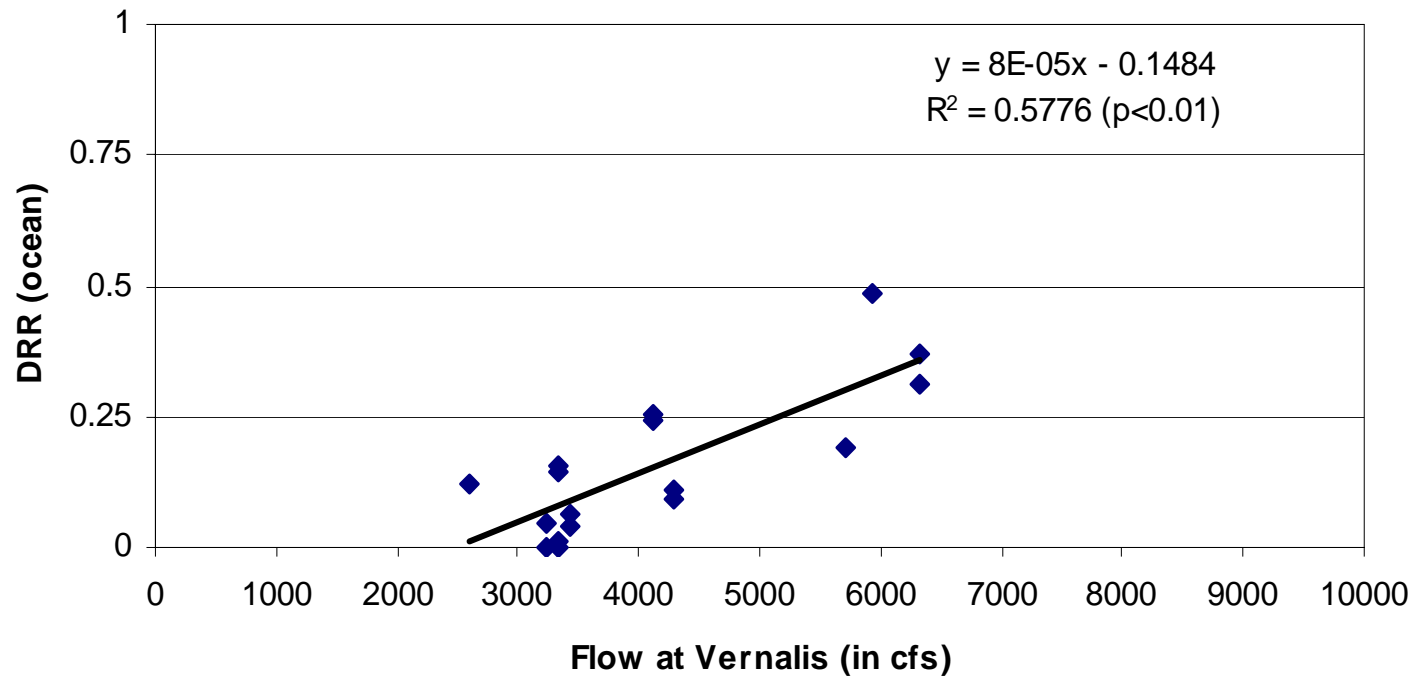


Figure 8: DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with the HORB in place.

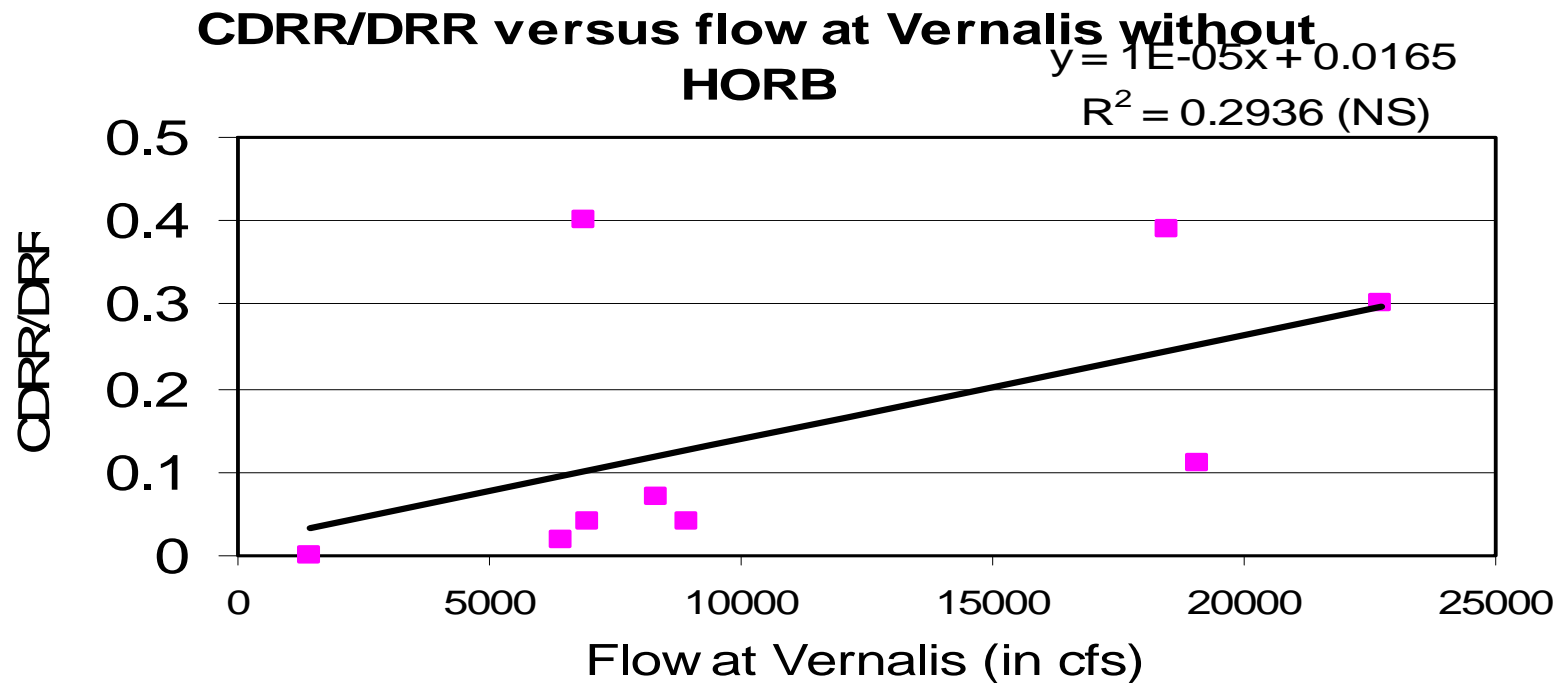


Figure 9: CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release without the HORB in place.

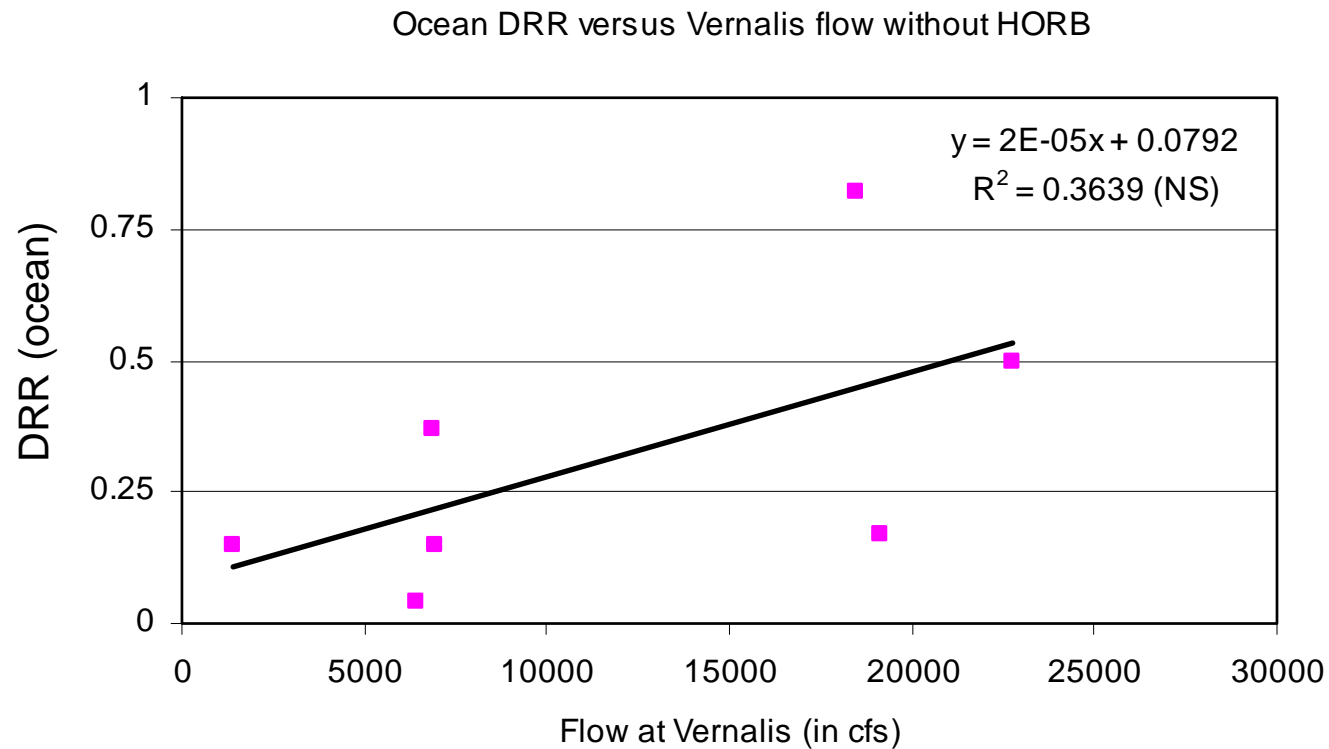


Figure 10: DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with and without the HORB in place.

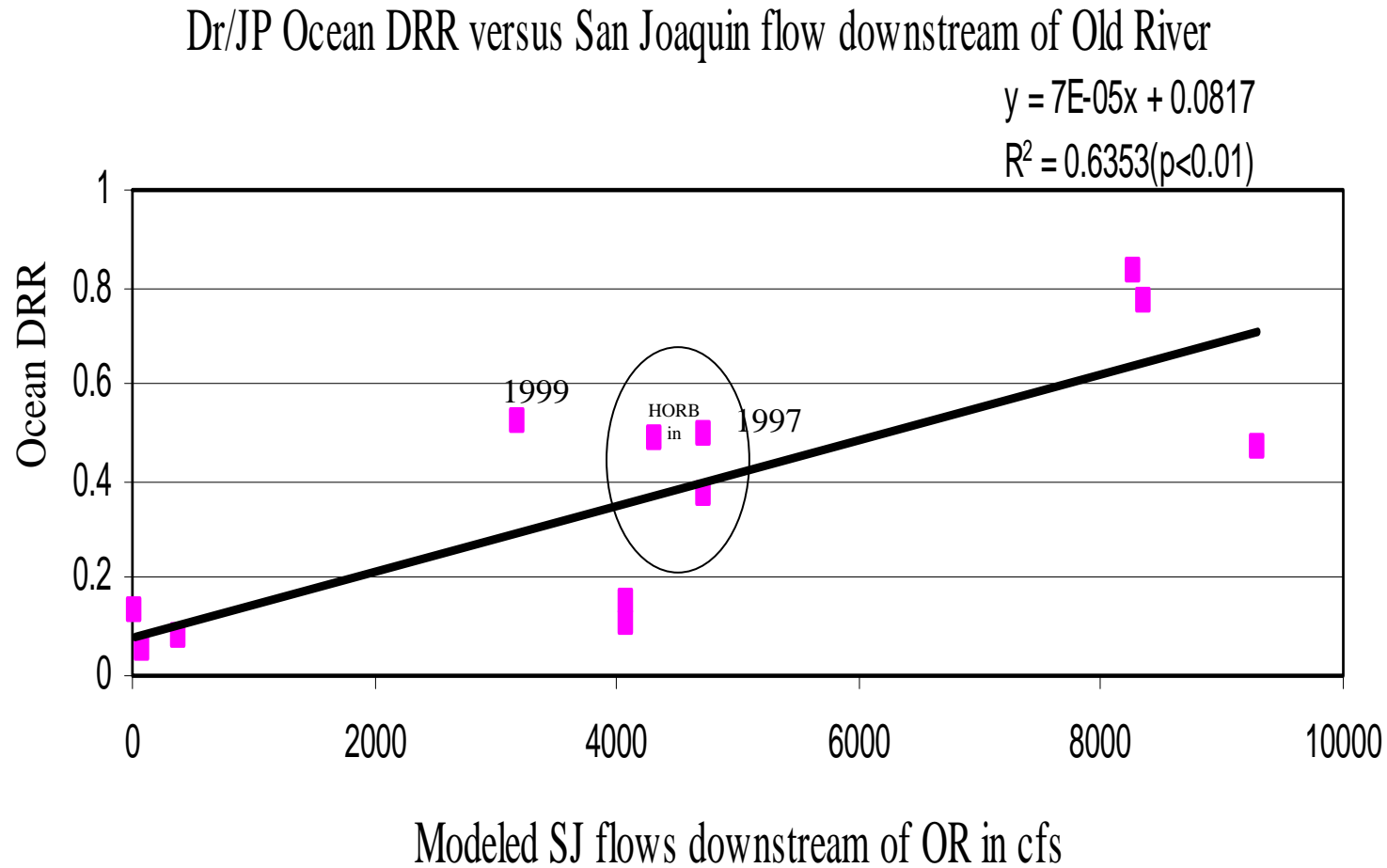


Figure 11: Ocean DRR measuring survival between Dos Reis and Jersey Point with and without a HORB and San Joaquin flows downstream of Old River

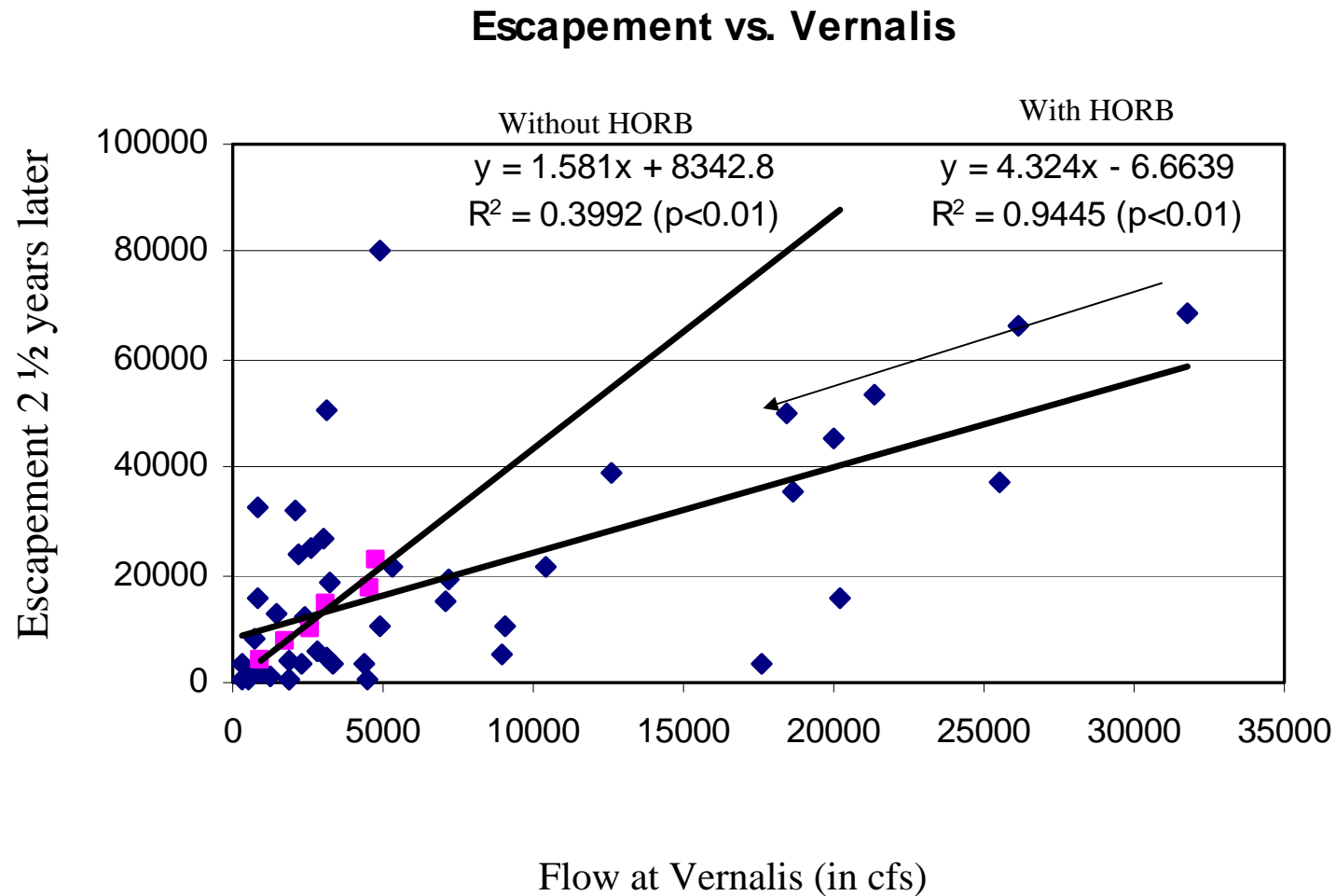


Figure 12: Vernalis flows versus escapement 2 1/2 years later in years with and without the HORB.

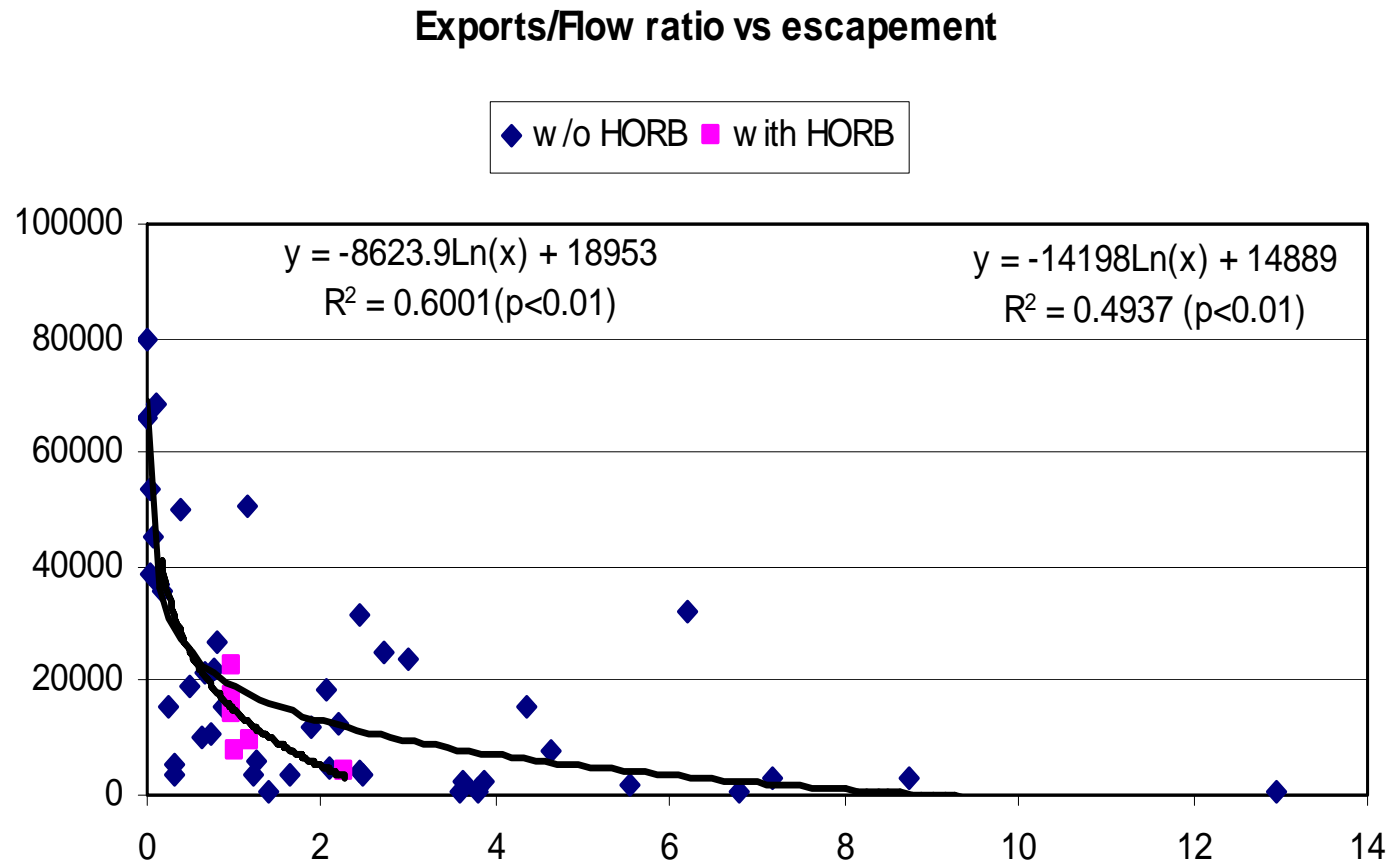


Figure 13: CVP+SWP Exports/Flow ratio versus adult escapement 2 ½ years later in years with and without the HORB in place.